REMARKS

By this Amendment, claims 1-4 are cancelled, and claims 5-9 are added. Thus, claims 5-9 are active in the application. Reexamination and reconsideration of the application are respectfully requested.

The specification and abstract have been carefully reviewed and revised in order to correct grammatical and idiomatic errors in order to aid the Examiner in further consideration of the application. The amendments to the specification and abstract are incorporated in the attached substitute specification and abstract. No new matter has been added.

Also attached hereto is a marked-up version of the substitute specification and abstract illustrating the changes made to the original specification and abstract.

On page 2 of the Office Action, claims 1-2 were objected to because of the identified informalities. This objection is believed to be moot in view of the cancellation of claims 1-2.

The objections raised by the Examiner with respect to claims 1-2 have been corrected in new claims 5-7, which have been added in favor of cancelled claims 1-2.

On page 3 of the Office Action, claims 1-4 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicant regards as the invention. This rejection is believed to be moot in view of the cancellation of claims 1-4.

Furthermore, the Applicant respectfully submits that new claims 5-9 have been drafted to correct each indefinite limitation in original claims 1-4. In particular, new claims 5-9 overcome the following issues raised by the Examiner.

(1) New claim 5 clearly recites that the extending circuit for memory is connected to an external FIFO circuit.

(2) The extending circuit for memory is also defined in claim 5 as comprising an internal FIFO circuit. For instance, Figure 1 illustrates that the extending circuit for memory 10 includes the internal FIFO circuit 1.

(3) New claim 5 recites in lines 19-21 that the output data effective signal generator causes the external FIFO circuit to perform a writing operation of writing the

input data into the external FIFO circuit, thus overcoming the issue raised by the Examiner with respect to line 7 of claim 1.

(4) The preamble of new claim 5 recites that data is input to the extending circuit for memory and that the data input to the extending circuit for memory is written to the external FIFO circuit.

(5) To clarify about where the input data is written, new claim 5 recites that the external FIFO circuit "can write data therein" and that the internal FIFO circuit "can write data therein," thus overcoming the issue raised by the Examiner as to where the external FIFO circuit writes data.

(6) New claim 7 recites the limitations that are addressed in the last paragraph on page 3 of the Office Action. New claim 6 recites that the internal FIFO circuit can having data written therein. Furthermore, lines 11-13 of new claim 7 recite that the internal FIFO read enable generator causes the internal FIFO circuit to perform a reading operation of reading the data written in the internal FIFO circuit. The output data generator is defined in lines 6-7 of new claim 7 as being operable to receive the data input to the extending circuit for memory, as illustrated in Figure 1 by the input data DIN. Furthermore, lines 19-21 of new claim 7 recite that the output data generator is operable to output, prior to the received data input to the external circuit for memory, the data written in the internal FIFO circuit and read out by the internal FIFO circuit to the external FIFO circuit.

(7) The issues raised by the Examiner in the first two paragraphs of page 4 of the Office Action have been overcome as new claims 5-9 consistently use a lowercase "e" when referring to the extending circuit for memory, and have remove all redundant references to the extending circuit for memory.

(8) The Examiner indicated that the word "effective" was not understood as used in original claims 1 and 3. The Examiner is respectfully requested to refer to reference numeral 2 at the bottom center portion of Figure 1. Reference numeral 2 denotes an "output data effective signal generator," which is an element comprised in the extending circuit for memory of the present invention. New claims 5-9 also recite the extending circuit for memory as comprising an output data signal generator, and thus, the term "effective" is used in the name of this element.

For at least the foregoing reasons, the Applicant submits that new claims 5-9 are clearly definite by particularly pointing out and distinctly claim the subject matter which the Applicant regards as the invention. Furthermore, new claims 5-9 were drafted to more positively attribute the functional language to the elements which perform the recited function, and thereby improve the readability of the claims.

Accordingly, the Applicant respectfully requests the Examiner to withdraw the indefiniteness rejection of the claims.

On page 5 of the Office Action, claims 1-2 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Steinmetz et al. (U.S. 5,809,521) in view of Jander et al. (U.S. 5,956,492). This rejection is believed to be moot with respect to claims 1-2 in view of the cancellation of these claims.

Furthermore, the Applicant submits that this rejection is inapplicable to new claims 5-9 for the following reasons.

The present invention provides an extending circuit for memory which is connected to an external FIFO circuit. The extending circuit for memory extends a memory capacity used for writing data to the extending external FIFO circuit.

The external circuit for memory includes an internal FIFO circuit, an output data effective signal generator, and an internal FIFO write enable generator. The output data effective signal and the internal FIFO write enable generator are each operable to receive a status signal from the external FIFO circuit indicating whether or not the external FIFO circuit can write data therein, i.e., whether the external FIFO circuit's memory is full and thus cannot receive data (an unwritable state), or whether the external FIFO circuit's memory is not full and thus can receive data (a writable state).

When the external FIFO circuit cannot write data therein based on the indication in the status signal, the internal FIFO write enable generator is operable to cause the internal FIFO generator to perform a writing operation of writing the input data (the data input to the external circuit for memory) into the internal FIFO circuit.

On the other hand, as described in lines 17-27 on page 11 of the original specification, for example, when the external FIFO circuit can write data therein based on the indication in the status signal, the output data generator is operable to output the input data to the external FIFO circuit directly without passing through the internal FIFO

circuit, and cause the external FIFO circuit to perform a writing operation of writing the input data into the external FIFO circuit.

Accordingly, when it is possible to write data into the external FIFO circuit, the extending circuit for memory of the present invention outputs the input data directly to the internal FIFO circuit by bypassing the internal FIFO circuit comprised in the extending circuit for memory.

As a result of this feature, it is possible to quickly process data from the external circuit for memory to the external FIFO circuit, while also providing the added effect of increasing memory capacity for the external FIFO circuit so that external FIFO circuit can process more data.

New claim 5 recites this feature of the present invention. In particular, new claim 5 recites that when the first status signal received by the output data effective signal generator indicates that the external FIFO can write data therein, the output data effective signal generator is operable to output the input data to the external FIFO circuit directly without passing through the internal FIFO circuit, and cause the external FIFO circuit to perform a writing operation of writing the input data into the external FIFO circuit.

Neither Steinmetz et al. nor Jander et al. disclose or suggest this feature of new claim 5.

Accordingly, no obvious combination of Steinmetz et al. and Jander et al. would result in the invention of new claim 5 since Steinmetz et al. and Jander et al., either individually or in combination, clearly fail to disclose or suggest each and every limitation recited in new claim 5.

Furthermore, it is submitted that because of the clear distinctions between the present invention as recited in new claim 5 and Steinmetz et al. and Jander et al., a person having ordinary skill in the art at the time the invention was made would not have been motivated to modify Steinmetz et al. and Jander et al. in such a manner as to result in, or otherwise render obvious, the present invention as recited in new claim 5.

Therefore, it is submitted that the new claim 5, as well as new claims 7-9 which depend therefrom, are clearly allowable over the prior art as applied by the Examiner.

In view of the foregoing amendments and remarks, it is respectfully submitted that the present application is clearly in condition for allowance. An early notice thereof is respectfully solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

A fee and a Petition for a one-month Extension of Time are filed herewith pursuant to 37 CFR § 1.136(a).

Respectfully submitted,

Hiroyasu NODA

By: _____

Jonathan R. Bowser
Registration No. 54,574
Attorney for Applicant

JRB/nrj
Washington, D.C. 20006-1021
Telephone (202) 721-8200
Facsimile (202) 721-8250
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Version with Markings to Show Changes Made

EXTENDING CIRCUIT FOR MEMORY AND TRANSMITTING-RECEIVING DEVICE USING EXTENDING CIRCUIT FOR MEMORY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an extending circuit for memory and a transmitting-receiving device using the extending circuit for memory that are applied in digital data communication or the like.

2. Description of the Related Art

In digital data communication, data processing speeds on a transmission side and a reception side should be equal ~~with~~ to each other in principle. Particularly in ~~In~~ fields of ~~particularly~~ mobile communication and the like, however, average data processing speeds on both sides are equal with each other, but the processing speeds on both sides are different for a short time. In such a case, FIFO (First In First Out) circuits are used in order to absorb the difference in the processing speeds. The FIFO circuits are first in first out circuits for literally outputting data according to an input order. As a memory capacity of the FIFO circuit ~~is~~becomes larger, a larger speed difference can be absorbed instantaneously. Enlargement of the memory capacity, however, causes a rise in the cost. Normally, a balance between the rise in the cost and the processing ability is considered according to applications or the like of the FIFO circuits, and the memory capacity is determined in a fixed manner. In the case where the application of the FIFO circuits is changed, some techniques for extending the memory capacity at a later time are disclosed (for example, see Japanese Patent Application Laid-Open No. 05-020864 (1993) as Patent Document 1 which relates to the

invention of this application).

In the above-mentioned prior technique, in the case or the like where the memory capacity of the FIFO circuit is insufficient, it is difficult to extend the memory capacity later. As mentioned in the Patent Document 1, some techniques for extending the memory capacity later are disclosed, but various restrictions are placed on the extension of the memory capacity. It is thus difficult to enlarge the memory capacity of the ~~existent~~ existing FIFO circuits instantly and simply.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to obtain an ~~E~~extending circuit for memory which is capable of enlarging the memory capacity instantly and simply as the need arises.

Further, there is a possibility that the memory capacity of either an existing ~~existent~~ transmission FIFO circuit or reception FIFO circuit is insufficient and the other one is sufficient depending on a change in a service condition of communication devices or the like. This state ~~is~~may be possibly reversed suddenly. In such a case, ~~it is also~~ the object of the present invention is also to realize a transmitting-receiving device using an extending circuit for memory which is capable of executing normal transmission and reception using a small memory capacity by instantly connecting the ~~E~~extending circuit for memory with the reception FIFO circuit or the transmission FIFO circuit in a switching manner.

According to ~~the~~a first aspect of the invention, to accomplish the above object, ~~there is provided~~ an extending circuit for memory is provided which has an internal FIFO circuit and is connected with an external FIFO circuit, in order to extend memory capacity used for writing input data~~,~~.

~~comprising:~~The extending circuit for memory

~~an~~comprises: an output data effective signal generator which, when~~,~~ ~~based on a status signal output from the external FIFO circuit, judged~~judging that the external FIFO circuit can write data, based on a status output from the external FIFO circuit, makes the external FIFO circuit perform a writing operation, ~~for outputting~~ and outputs the input data into the external FIFO circuit; and

an internal FIFO write enable generator which, when~~, based on the status signal output from the external FIFO circuit, judged~~judging that the external FIFO circuit can not write data, based on the status signal output from the external FIFO circuit, makes the internal FIFO circuit perform a writing operation, ~~for writing~~ and writes the input data into the internal FIFO circuit of the extending circuit for memory.

Further, the extending circuit for memory may also comprises~~:~~

an internal FIFO read enable generator which, when~~, based on the status signal output from the external FIFO circuit and a status signal output from the internal FIFO circuit, judged~~ judging that the external FIFO circuit can write data and the internal FIFO circuit ~~is having~~ has memory data, based on the status signal output from the external FIFO circuit and a status signal output from the internal FIFO circuit, makes the internal FIFO circuit perform a reading operation, ~~for read~~reads the memory data out from the internal FIFO circuit, and ~~outputting~~ outputs the memory data to the external FIFO circuit; and

an output data generator which, when the external FIFO circuit is judged ~~being~~to be able to write data~~;~~, ~~and~~ the internal FIFO circuit is judged as having memory data~~;~~ and the input data is received, outputs, prior to the input data, the memory data read out from the internal FIFO circuit to the

external FIFO circuit.

According to ~~the~~a second aspect of the invention, to accomplish the above object, there is provided a transmitting-receiving device using an extending circuit for memory for enabling the ~~E~~extending circuit for memory ~~according to the~~ as described above ~~Extending circuit for memory~~ to be connected with either a transmission FIFO circuit or a reception FIFO circuit in a switching manner in order to extend a memory capacity~~,~~. ~~t~~The transmitting-receiving device ~~using extending circuit for memory using~~ uses the ~~E~~extending circuit for memory ~~comprising~~and comprises:

——— a first selector for enabling either a transmission signal system or a reception signal system to be connected with the ~~E~~extending circuit for memory in a switching manner;

——— a second selector for enabling a status signal from either the transmission FIFO circuit or the reception FIFO circuit to be connected with the internal FIFO write enable generator, the output data effective signal generator, and the internal FIFO read enable generator of the ~~E~~extending circuit for memory in a switching manner;

a third selector for enabling the transmission FIFO circuit to be connected with either the output data generator and the output data effective signal generator of the ~~E~~extending circuit for memory or the transmission signal system in a switching manner; and

a fourth selector for enabling the reception FIFO circuit to be connected with either the output data generator and the output data effective signal generator of the ~~E~~extending circuit for memory or the reception signal system in a switching manner.

Further, the transmitting-receiving device using the extending circuit for memory ~~using the Extending circuit for memory~~ may comprises:

———a control section for:

receiving status signals from the transmission FIFO circuit and the reception FIFO circuit, ~~when the transmission FIFO circuit is in a data writable state and the reception FIFO circuit is in a data unwritable state,~~ connecting the first selector with the reception signal system and connecting the second and the third selectors with the reception selector in a switching manner when the transmission FIFO circuit is in a data writable state and the reception FIFO circuit is in a data unwritable state, and

receiving the status signals from the transmission FIFO circuit and the reception FIFO circuit, ~~when the reception FIFO circuit is in a data writable state and the transmission FIFO circuit is in a data unwritable state,~~ connecting the first selector with the transmission signal system and connecting the second and the third selectors with the transmission selector in a switching manner, when the reception FIFO circuit is in a data writable state and the transmission FIFO circuit is in a data unwritable state.

The above and other objects and features of the present invention will become apparent from the following detailed description and the appended claims with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a constitution according to a concrete first example ~~1~~.

Fig. 2 is a time chart of an internal FIFO circuit.

Fig. 3 is a time chart of an ~~E~~extending circuit for memory.

Fig. 4 is a connecting diagram of ~~an~~ a FIFO module using the ~~E~~extending circuit for memory.

Fig. 5 is a block diagram of a transmitting-receiving device using the

~~extending circuit for memory using the E~~extending circuit for memory.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention are explained below ~~by giving~~in the form of concrete examples.

~~(~~Concrete First Example 1~~)~~

In this concrete example, in order to ~~extending~~ extend memory capacity with respect to an ~~existent~~ existing FIFO circuit, an extending circuit for memory is provided~~,~~ which is capable of realizing the extension of memory by connecting instantly and simply to the ~~existent~~ existing FIFO circuit. Accordingly, with respect to the extending circuit for memory, the ~~existent~~ existing FIFO circuit is used as an external FIFO circuit, i.e. a next-stage FIFO circuit.

The following four functions are added to the ~~E~~extending circuit for memory in order to maintain a first in first out principle. (1) When a next-stage FIFO circuit is in a writable state, namely, the next-stage FIFO circuit is empty, input data are transmitted directly to the next-stage FIFO circuit. (2) When the next-stage FIFO circuit is in an unwritable state, namely, the next-stage FIFO circuit is full (not empty), input data are stored into an internal FIFO circuit.

(3) When the next-stage FIFO circuit is in a writable state, namely, the next-stage FIFO circuit is empty and data are stored in the internal FIFO circuit, the data stored in the internal FIFO circuit are transmitted to the next-stage FIFO circuit . (4) When the next-stage FIFO circuit is in a writable state, namely, the next-stage FIFO circuit is empty, data are stored in the internal FIFO circuit and the circuit receives the input data, the data stored in the internal FIFO circuit, serving as memory data, are transmitted to the

next-stage FIFO circuit preferentially.

Further, the internal FIFO circuit and the added circuits for adding the above four functions are blocked so that they can be connected with before and after the ~~existent~~ existing FIFO circuit instantly and simply. An Input/Output node of the block is made to be similar to the ~~existent~~ existing FIFO circuit. In order to achieve the above object, the ~~E~~extending circuit for memory of the concrete example is constituted as follows.

Fig. 1 is a block diagram of the constitution according to the first concrete example~~-1~~.

According to Fig. 1, the ~~E~~extending circuit for memory 10 of the first concrete example~~-1~~ comprises an internal FIFO circuit 1, an output data effective signal generator 2, an internal FIFO write enable generator 3, an internal FIFO read enable generator 4, and an output data generator 5.

The internal FIFO circuit 1 is similar to a prior (~~existent~~existing) FIFO circuit, and has a CLK node for receiving a clock signal, a WE node for receiving a write enable signal, a RE node for receiving a read enable signal, a DIN node for receiving input data, a DOUT node for outputting data, and a ST node for outputting a difference between an internal write counter value and a read counter value as status signals.

The ~~T~~timing of signals at the respective nodes is explained with reference to the drawings.

Fig. 2 is a time chart of the internal FIFO circuit 1.

Fig. 2 shows signal states at the CLK node, the WE node, the RE node, the DIN node, the DOUT node, the ST node, the write counter and the read counter in this order ~~from top~~. The bottom part of Fig. 2shows common time areas in the respective signal states. One example of the respective signal states in the respective time areas is explained. Low level (L level) at the WE

node and the RE node are in an assertion state.

· Time area "a"

Since both the WE node and the RE node are at a high level (H level) and both the write counter and the read counter indicate zero, the ST node is maintained at 0.

. Time area "b"

The WE node is asserted (L level), and data 0 are input into the DIN node. The data 0 are stored in an internal memory (not shown).

· Time area "c"

The write counter counts the data 0 in the time area "b" ~~with~~ as being delayed by one clock so as to indicate 1. The ST node, therefore, becomes 1.

· Time area "d"

While the WE node is at H level, the RE node is asserted (L level), and the data 0 stored in the internal memory are output from the DOUT node.

· Time area "e"

While the RE node is at H level, the WE node is asserted, and data 1 are output into the DIN node. The data 1 are stored in the internal memory. The read counter counts the data 0 in the time area "d" ~~with~~ as being delayed by one clock so as to indicate 1. The ST terminal, therefore, becomes 0.

· Time area "f"

The WE node is asserted and data 2 are input into the DIN node. The data 2 are stored in the internal memory. Further, the RE node is asserted, and the data 1 stored in the time area "e" are output from the DOUT node. The write counter counts the data 1 in the time area "e" ~~with~~ as being delayed by one clock so as to indicate 2. The ST counter, therefore, becomes 1.

· Time area "g"

While the WE node is at H level, the RE node is asserted, and the data 2

stored in the time area "f" are output from the DOUT node. The write counter counts the data 2 in the time area "f" ~~with~~ as being delayed by one clock so as to indicate 3. The read counter counts the data 1 in the time area "f" ~~with~~ as being delayed by one clock so as to indicate 2. The ST counter, therefore, becomes 1.

~~The~~A similar operation is repeated until the time area "h".

As explained above, when the WE node is at L level (asserted), the input data (DIN) into the internal FIFO circuit 1 synchronize with a clock signal (CLK) so as to be stored in the internal memory. When the input data are stored, the write counter increases by one ~~with~~as being delayed by one clock. Moreover, when the RE node is at L level (asserted), the data stored in the internal memory are read in synchronization with the clock signal (CLK). Further, the status signal (ST) represents a difference between a counted value of the write counter and a counted value of the read counter, namely, a quantity of the data stored in the internal memory.

Again with reference to Fig. 1, the explanation as to the constitution of the first concrete example ~~1~~ is continued.

The output data effective signal generator 2 receives (monitors) a status signal (STNS) of a next-stage FIFO circuit, and asserts a next-stage FIFO write enable signal (WEn) when data can be written into the next-stage FIFO circuit so as to enable the data to be written into the next-stage FIFO circuit. That is to say, the output data effective signal generator 2 outputs an output data effective signal NWEO representing whether data (DOUT) to be output to the ~~E~~extending circuit for memory 10 is effective or ineffective. The output data effective signal NWEO functions as a write enable signal (WEn) at the next stage.

A write enable signal (WEp) transmitted from a previous stage to the

~~E~~extending circuit for memory 10, a status signal S1 from the internal FIFO circuit, a status signal STNF from a next-stage FIFO circuit, and an internal FIFO read enable signal S2 output by the internal FIFO read enable generator 4, ~~mentioned later~~as described below, are input into the output data effective signal generator 2. When the internal FIFO read enable signal S2 is asserted (L level) or the next-stage FIFO circuit is in a data writable state, namely, when the status signal of the next-stage FIFO is at H level, the output data effective signal NWEO becomes L level. This state is equivalent to ~~that~~ the write enable signal (WEn) from the next-stage FIFO circuit ~~is~~ being asserted.

The internal FIFO write enable generator 3 receives (monitors) the status signal (STNS) from the next-stage FIFO circuit, and asserts an internal FIFO write enable signal (S3) when the next-stage FIFO circuit is in a data unwritable state, so as to enable input data (DIN) to be written into the internal FIFO circuit 1. A status signal (STNS) from the next-stage FIFO circuit and an internal FIFO read enable signal S2 output by the internal FIFO read enable generator 4, ~~mentioned later~~as described below, are input into the internal FIFO write enable generator 3.

When the next-stage status signal (STNF) is at L level (a next-stage memory is full), the internal FIFO write enable generator 3 receives the write enable signal WEp from the previous stage, and asserts (L level) the internal FIFO write enable signal (S3). Moreover, ~~also~~ when the internal FIFO read enable signal S2 output by the internal FIFO read enable generator 4 is asserted, the internal FIFO write enable generator 3 receives the write enable signal WEp from the previous stage and asserts (L level) the internal write enable signal (S3).

The internal FIFO read enable generator 4 receives (monitors) a status

signal (STNF) from the next-stage FIFO circuit. When the next-stage FIFO circuit is in a data writable state, the internal FIFO read enable generator 4 receives (monitors) the status signal (S1) from the internal FIFO circuit 1, and the internal memory is not empty, the internal FIFO read enable generator 4 asserts the internal FIFO read enable signal (S2) so as to output the data stored in the memory.

The output data generator 5 receives input data and outputs the input data to the next-stage FIFO circuit, and preferentially reads the data stored in the internal FIFO circuit 1 instead of the input data so as to output them to the next-stage FIFO circuit when the internal FIFO read enable signal is asserted. This output becomes input data (DINn) into a next-stage FIFO circuit.

All the above components are integrated or made into a module, so as to compose the ~~E~~extending circuit for memory 10. The node DIN receives input data, the node WCLK receives a clock signal, the node WEp receives a previous-stage write enable signal, a node ST outputs a status signal, a node STNF receives a status signal from a next-stage FIFO circuit, a node NWEO outputs a write enable signal to the next-stage FIFO circuit, and the node DOUT outputs next-stage FIFO data.

~~(~~Operation of the First Concrete Example~~1)~~

Fig. 3 is a time chart of the ~~E~~extending circuit for memory.

Fig. 3 shows states of a clock signal (CLK), a write enable input signal (WEp), an internal FIFO read enable signal (S2), an internal FIFO write enable signal (S3), a next-stage FIFO status signal (STNF), an output data effective signal (NWEO), an input data (DIN), an internal FIFO output data (S4), an output data (DOUT), and an internal FIFO status signal (S1) in this order ~~from the top~~. The bottom portion of Fig. 3shows time areas common in

the respective signals. L levels of the signals WEp, S2 and S3 are in an assertion state. When the STNF signal is at L level, the next-stage FIFO circuit is full (in an unwritable state). One example of the signal states in the time areas is explained.

· Time area A

The write enable signal (WEp) is asserted, and 0 is received as input data (DIN). Since a next-stage FIFO status signal (STNF) is at H level, the next-stage FIFO circuit is in a data writable state. The input data (DIN0), therefore, are not stored in the internal FIFO circuit and pass directly through the output data generator 5 so as to be output (DOUT) as input data (DINn). Moreover, since the next-stage FIFO circuit is in a data writable state (STNF is at H level), the output data effective signal generator 2 sets the output data effective signal (NWE0) at L level. This state is such that the write enable signal (WEn) from the next-stage FIFO circuit is asserted.

· Time area B

The write enable signal (WEp) is asserted, but since the next-stage FIFO status signal (STNF) is at L level, the next-stage FIFO circuit is in a data unwritable state. The output data effective signal generator 2, therefore, sets the output data effective signal (NWEO) at H level. This state is such that the write enable signal (WEn) from the next-stage FIFO circuit is not asserted. Alternatively, the internal FIFO write enable generator 3 asserts the internal FIFO write enable signal (S3). As a result, data 1 as the input data (DIN) are stored in the internal FIFO circuit 1.

· Time area C

The write enable signal (WEp) is asserted, but the internal FIFO read enable signal (S2) is also asserted. Moreover, since the next-stage FIFO status signal (STNF) is at H level, the next-stage FIFO circuit is in a data

writable state. In this case, the output data generator 5 ~~firstly~~first reads the data 1 stored in the internal FIFO circuit 1 (S4), and transmits the data 1 as output data (DOUT) to the next-stage FIFO circuit. Data 2 as input data (DIN) are stored in the internal FIFO circuit 1. Further, the write counter of the internal FIFO circuit 1 counts the data 1 received in the time area B ~~with~~as being delayed by one clock so as to indicate 1. The internal FIFO status signal (S1), therefore, becomes 1.

· Time area D

The internal FIFO read enable signal (S2) is asserted. Moreover, since the next-stage FIFO status signal (STNF) is at H level, the output data generator 5 reads the data 2 stored in the internal FIFO circuit 1 (S4) and transmits the data 2 as the output data (DOUT) to the next-stage FIFO circuit. Further, the write counter of the internal FIFO circuit 1 counts the data 2 received in the time area C ~~with~~as being delayed by one clock so as to indicate 2. Further, the read counter of the internal FIFO circuit 1 counts the data 1 read in the time area C ~~with~~as being delayed by one clock so as to indicate 1. The internal FIFO status signal (S1), therefore, becomes 1.

· Time area E

The write enable signal (WEp) is asserted, but since the next-stage FIFO status signal (STNF) is at L level, the internal FIFO write enable generator 3 asserts the internal FIFO write enable signal (S3). As a result, the data 3 as the input data (DIN) are stored in the internal FIFO circuit 1. Moreover, the read counter of the internal FIFO circuit 1 counts the data 2 read in the time area D ~~with~~ as being delayed by one clock so as to indicate 2. The internal FIFO status signal (S1), therefore, becomes 0.

· Time area F

Since data 3 are stored in the internal FIFO circuit 1 and the next-stage

FIFO status signal (STNF) is at H level, the internal FIFO read enable generator 4 asserts the internal FIFO read enable signal (S2). As a result, the output data generator 5 reads the data 3 stored in the internal FIFO circuit 1 (S4), and transmits the data 3 as the output data (DOUT) to the next-stage FIFO circuit. Moreover, the read counter of the internal FIFO circuit 1 has already counted the data 3 read in the time area E ~~with~~ as being delayed by one clock so as to indicate 3. The internal FIFO status signal (S1) is, therefore, 1.

· Time area G

The write enable signal (WEp) is asserted, but since the next-stage FIFO status signal (STNF) is at L level, the internal FIFO write enable generator 3 asserts the internal FIFO write enable signal (S3). As a result, data 4 as the input data (DIN) are stored in the internal FIFO circuit 1. Moreover, the read counter of the internal FIFO circuit 1 has counted the data 3 read in the time area F ~~with~~ as being delayed by one clock so as to indicate 3. The internal FIFO status signal (S1) is, therefore, 0.

· Time area H

Since the data 4 are stored in the internal FIFO circuit 1 and the next-stage FIFO status signal (STNF) is at H level, the internal FIFO read enable generator 4 asserts the internal FIFO read enable signal (S2). As a result, the output data generator 5 reads the data 4 stored in the internal FIFO circuit 1 (S4), and transmits the data 4 as the output data (DOUT) to the next FIFO circuit. Further, the write counter of the internal FIFO circuit 1 has already counted the data 4 read in the time area G ~~with~~ as being delayed by one clock so as to indicate 4. Further, the read counter of the internal FIFO circuit 1 has already counted the data 3 read in the time area F ~~with~~ as being delayed by one clock so as to indicate 4. The internal FIFO status signal (S1) is,

therefore, 0.

The above-mentioned operation of the first concrete example ~~1~~ is compiled so as to be summarized in the following logic.

(1) When the next-stage FIFO circuit is in a writable state, namely, when the next-stage FIFO circuit is empty, the ~~E~~extending circuit for memory transmits input data directly to the next-stage FIFO circuit. The time area A in Fig. 3 corresponds to this case.

(2) When the next-stage FIFO circuit is in an unwritable state, namely, the next-stage FIFO circuit is full (not empty), the ~~E~~extending circuit for memory stores the input data into the internal FIFO circuit 1. The time areas B and E in Fig. 3 correspond to this case.

(3) When the next-stage FIFO circuit is in a writable state, namely, when the next-stage FIFO circuit is empty and data are stored in the internal FIFO circuit, the ~~E~~extending circuit for memory transmits the data stored in the internal FIFO circuit to the next-stage FIFO circuit. The time areas F and H in Fig. 3 correspond to this case.

(4) When the next-stage FIFO circuit is in a writable state, namely, when the next-stage FIFO circuit is empty and data are stored in the internal FIFO circuit and the input data are received, the ~~E~~extending circuit for memory preferentially transmits the data stored in the internal FIFO circuit to the next-stage FIFO circuit. The time area C in Fig. 3 corresponds to this case.

In the above explanation, the ~~E~~extending circuit for memory is operated by one clock signal (CLK), but the present invention is not limited to this example. That is to say, the clock signal of the data input is not necessarily equal with the clock signal of the data output, and thus clock signals with different timings may be used. Moreover, in the above explanation, the status

signal (ST) represents a quantity of the data stored in the internal memory, but the present invention is not limited to this example. That is to say, any signal may be used as long as it can be used to discriminate whether the internal memory is full or empty.

Further, the above explanation refers to only the case where one ~~E~~extending circuit for memory of the present invention is added before and after the ~~existent~~ existing FIFO circuit, but the present invention is not limited to this example. Another example is explained with reference to ~~the drawing~~Fig. 4.

Fig. 4 is a connecting diagram of an FIFO module using the ~~E~~extending circuit for memory.

As shown in Fig. 4, the ~~E~~extending circuits for memory~~s~~ 10-1 to 10-n of the present invention are connected with the ~~existent~~ existing FIFO circuit 11 in a dependent manner, so that an FIFO module using the ~~E~~extending circuits for memory~~s~~ can be constituted.

As shown in Fig. 4, DIN of the ~~existent~~ existing FIFO circuit 11 is connected with DOUT of the ~~E~~extending circuit for memory 10-1, WE of the ~~existent~~ existing FIFO circuit 11 is connected with NWEO of the ~~E~~extending circuit for memory 10-1, and ST of the ~~existent~~ existing FIFO circuit 11 is connected with STNF of the ~~E~~extending circuit for memory 10-1. In the connection between the ~~E~~extending circuits for memory~~s~~, DIN of the next-stage ~~E~~extending circuit for memory is connected with DOUT of the previous-stage FIFO circuit, WEp of the next-stage ~~E~~extending circuit for memory is connected with NWEO of the previous-stage ~~E~~extending circuit for memory, and ST of the next-stage ~~E~~extending circuit for memory is connected with STNF of the previous-stage ~~E~~extending circuit for memory. Further, a clock signal is supplied to all the FIFO circuits. In such a manner, the extended

FIFO module can be constituted easily.

As explained above, when the extending circuit for memory is constituted, as shown in Fig. 4, the extending circuits for memorys are connected in the dependent manner, so that the extended FIFO module can be constituted easily. Moreover, an extending circuit for memory 10-(n + 1) can be easily added to the extended FIFO module. As a result, when the memory capacity of the FIFO circuit is insufficient, the memory capacity can be increased instantly and easily as the need arises.

In this case, with respect to the extending circuit for memory 10-(n + 1), the extending circuit for memory 10-n ~~became~~ becomes the external FIFO circuit, i.e., the next-stage FIFO circuit.

Moreover, with respect to the previous-stage extending circuit, the next-stage extending circuit for memory is used as the external FIFO circuit.

~~(~~Second Concrete Example ~~2)~~

In this concrete example, the transmitting-receiving device using the extending circuit for memory which is capable of carrying out transmission and reception using the FIFO circuit with a small memory capacity is realized. There is a possibility that the memory capacity of either the ~~existent~~ existing transmission FIFO circuit or reception FIFO circuit is insufficient, and the other memory capacity is enough according to a change in the service condition of the communication device. Further, this situation may be abruptly reversed. In such a case, the ~~E~~extending circuits for memorys realized in the first concrete example ~~1~~ can be connected with the reception FIFO circuit or the transmission FIFO circuit in a switching manner. In order to achieve this object, the transmitting-receiving device using the extending circuit for memory in this concrete example is constituted as follows.

Fig. 5 is a block diagram of the transmitting-receiving device using the extending circuit for memory ~~using the Extending circuit for memory~~.

With reference to Fig. 5, the transmitting-receiving device using the extending circuit for memory ~~using the Extending circuit for memory~~ comprises an ~~E~~extending circuit for memory 10, a transmission FIFO circuit 21, a reception FIFO circuit 22, a first selector 23, a second selector 24, a third selector 25 and a fourth selector 26.

The first selector 23 can connect either a transmission signal system 27 or a reception signal system 28 with the ~~E~~extending circuit for memory 10 in a switching manner.

The second selector 24 can connect a status signal from either the transmission FIFO circuit 21 or the reception FIFO circuit 22 with the internal FIFO write enable generator 3 (Fig. 1), the output data effective signal generator 2 (Fig. 1), and the internal FIFO read enable generator 4 (Fig. 1) of the ~~E~~extending circuit for memory 10 in a switching manner.

The third selector ~~3~~26 can connect either the output data generator 5 (Fig. 1) and the output data effective signal generator 2 (Fig. 1) of the ~~E~~extending circuit for memory 10 or the transmission signal system 27 with the transmission FIFO circuit 21 in a switching manner.

The fourth selector ~~4~~26 can connect either the output data generator 5 (Fig. 1) and the output data effective signal generator 2 (Fig. 1) of the ~~E~~extending circuit for memory 10 or the transmission signal system 28 with the transmission FIFO circuit 22 in a switching manner.

The first selector 23, the second selector 24, the third selector 25 and the fourth selector 26 are switched so that the ~~E~~extending circuit for memory 10 can be connected with either the transmission FIFO circuit 21 or the reception FIFO circuit 22. As a result, in the case where the memory capacity

of the transmission FIFO circuit 21 is insufficient and the memory capacity of the reception FIFO circuit 22 is sufficient, the ~~E~~extending circuit for memory 10 can be connected with the transmission FIFO circuit 21. Further, in the case where the memory capacity of the transmission FIFO circuit 21 is sufficient and the memory capacity of the reception FIFO circuit 22 is insufficient, the ~~E~~extending circuit for memory 10 can be connected with the reception FIFO circuit 22.

The memory capacity of the transmission FIFO circuit 21 and the memory capacity of the reception FIFO circuit 22 are determined as to their sufficient/insufficient state based on the respective status signals. A control unit for automatically switching the first selector 23, the second selector 24, the third selector 25, and the fourth selector 26 is further provided, so that the transmitting-receiving device using the extending circuit for memory, which is capable of switching more accurately at higher speed, can be obtained.

The above explanation refers to only the switching between the two FIFO circuits of the transmission FIFO circuit 21 and the reception FIFO circuit 22, but the present invention is not limited to this example. That is to say, the switching among three or more FIFO circuits can be realized by ~~the~~a similar technique.

The constitution of the second concrete example ~~2~~ explained above is adopted, so that the ~~E~~extending circuit for memory can be connected with either the transmission FIFO circuit or the reception FIFO circuit. For this reason, in the case where the memory capacity of the transmission FIFO circuit is insufficient and the memory capacity of the reception FIFO circuit is sufficient, the ~~E~~extending circuit for memory can be connected with the transmission FIFO circuit. Moreover, in the opposite case, the ~~E~~extending circuit for memory can be connected with the reception FIFO circuit. As a

result, the memory capacity of the ~~E~~extending circuit for memory can be utilized effectively.

EFFECTS OF THE INVENTION

The ~~E~~extending circuit for memory according to the present invention is constituted as explained above, so that the following effects can be obtained.

1. The ~~E~~extending circuit~~s~~ for memory~~s~~ are connected in a dependent manner so that the extended FIFO module can be constituted easily.

2. The ~~E~~extending circuit for memory can be further added to the extended FIFO module easily.

3. As a result, in the case where the memory capacity of the FIFO circuit is insufficient, the memory capacity can be increased at a later time instantly and easily as the need arises.

4. Further, the ~~E~~extending circuit for memory of the present invention is used in the transmitting-receiving device using extending circuit for memory and connected with the reception FIFO circuit or the transmission FIFO circuit instantly in a switching manner, so that the ~~E~~extending circuit for memory can be connected with either the transmission FIFO circuit or the reception FIFO circuit. For this reason, in the case where the memory capacity of the transmission FIFO circuit is insufficient and the memory capacity of the reception FIFO circuit is sufficient, the ~~E~~extending circuit for memory can be connected with the transmission FIFO circuit. Further, in the opposite situation, the ~~E~~extending circuit for memory can be connected with the reception FIFO circuit. As a result, the memory capacity of the ~~E~~extending circuit for memory can be utilized effectively.

ABSTRACT ~~OF THE DISCLOSURE~~

An ~~E~~extending circuit for memory ~~comprises~~includes: an output data effective signal generator ~~2~~ for, when a status signal ~~STNF~~ from a next-stage FIFO circuit represents a data writable state, asserting a write enable signal ~~NWEO~~ from the next-stage FIFO circuit, and enabling data to be written into the next-stage FIFO circuit; ~~and~~ The extending circuit for memory also includes an internal FIFO write enable generator ~~3~~ for receiving a status signal ~~STNF~~ from the next-stage FIFO circuit, ~~when the next-stage FIFO circuit is in a data unwritable state,~~ asserting an internal FIFO write enable signal ~~S3~~, and enabling data to be written into ~~the~~an internal FIFO circuit of the extending circuit for memory, ~~1~~ when the next-stage FIFO circuit is in a data unwritable state.